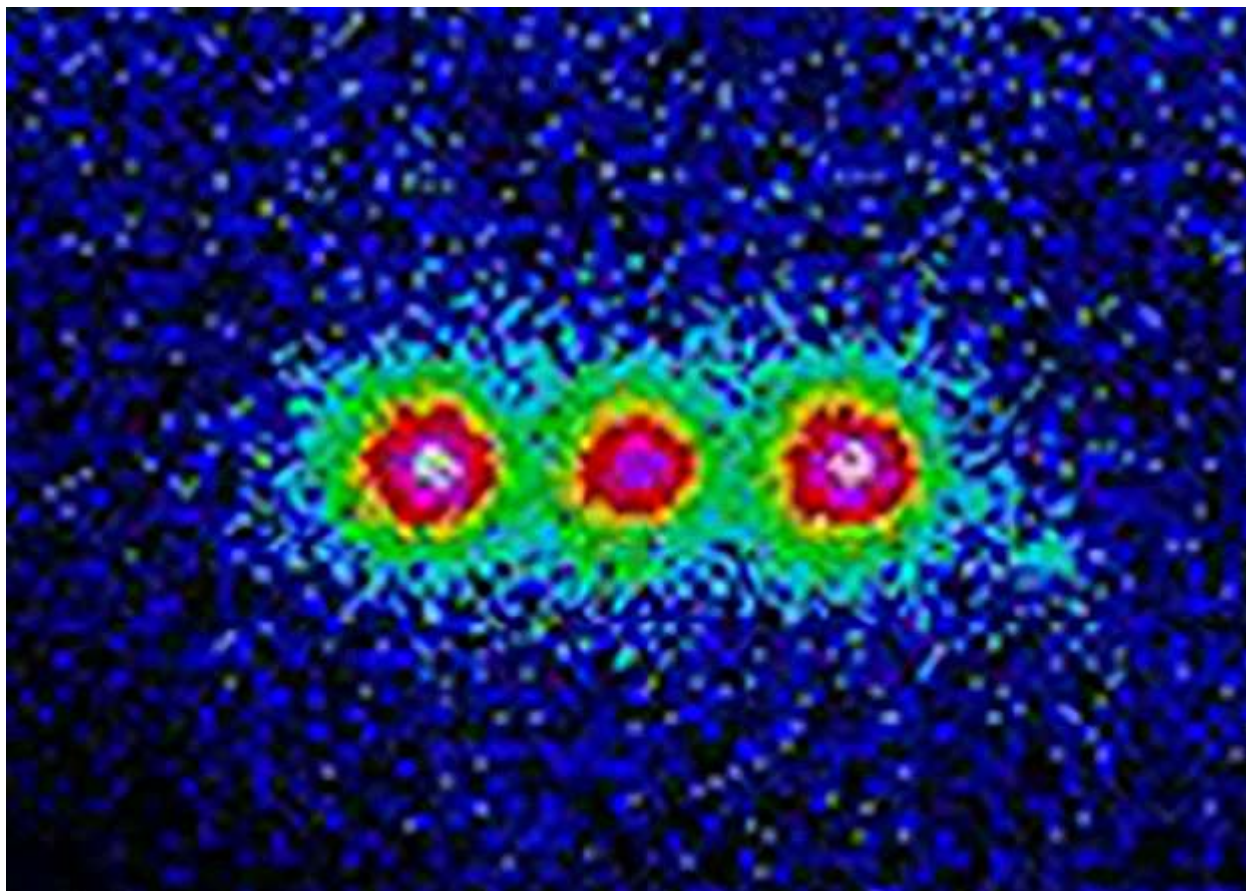


Pre-AP Chemistry

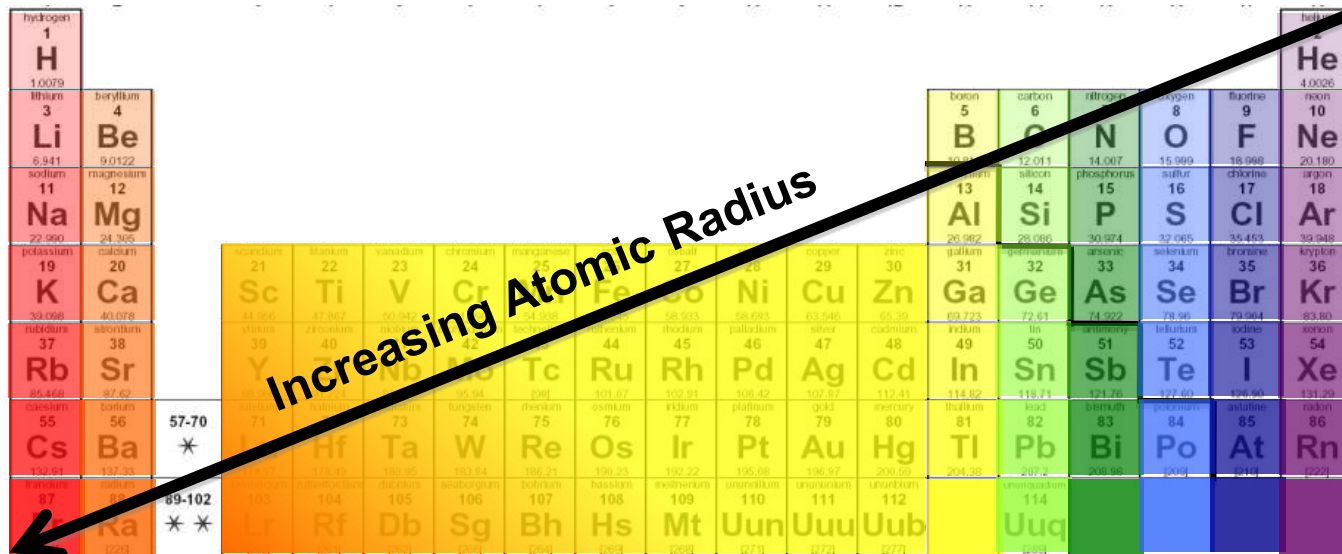
September 4, 2011

11. Periodic Table III



Review

- Many elemental properties follow periodic trends across the rows and columns of the Periodic Table
- Atomic radii increase going down and to the left on the Periodic Table



* Lanthanide series

lanthanum	cerium	praseodymium	neodymium	promethium	samarium	europium	gadolinium	terbium	dysprosium	holmium	erbium	thulium	ytterbium
La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb
138.91	140.12	140.91	144.24	[145]	150.36	151.96	157.25	158.93	162.50	164.93	167.26	168.93	173.04
actinium	thorium	protactinium	uranium	neptunium	plutonium	americium	curium	berkelium	californium	einsteinium	fermium	mendelevium	nobelium
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No
[227]	232.04	231.04	238.03	[237]	[244]	[243]	[247]	[247]	[251]	[252]	[257]	[258]	[259]

** Actinide series

What is responsible for the increase in atomic radii in a row? In a column?

Review

- Place the following elements in order of increasing atomic radii:

Mg

Na

Ne

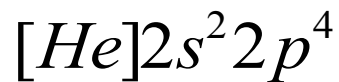
F

O

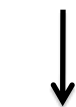
Review

- What is the electron configuration for each atom after ...

O



...
adding 2
electrons?



O²⁻

?

F



...
adding 1
electron?



F⁻

?

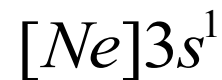
Ne



Ne

?

Na



...
removing 1
electron?



Na⁺

?

Mg



...
removing 2
electrons?

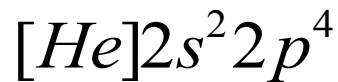


Mg²⁺

?

Review

O



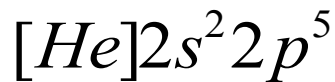
+ 2 e⁻



O²⁻



F



+ 1 e⁻



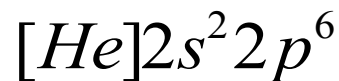
F⁻



Ne



Ne



Na



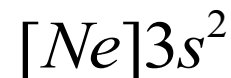
- 1 e⁻



Na⁺



Mg



- 2 e⁻



Mg²⁺



These ions and atoms are all **isoelectronic**.

Today we will learn trends in their (ionic) radii and reactivity.

Outline

- Special Groups
- Salts
- Ionic Radii

- Special Groups
 - Noble Gases
 - Alkali Metals
 - Halogens
- Salts
- Ionic Radii

Outline

- Special Groups
- Salts
- Ionic Radii

- Special Groups
 - Noble Gases
 - Alkali Metals
 - Halogens
- Salts
- Ionic Radii

Periodic Table

- Special Groups: What properties do the elements in each have in common? What is the origin of these common properties?

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1 H Hydrogen 1.00794	Atomic # Symbol Name Atomic Mass																2 He Helium 4.002602	
3 Li Lithium 6.941	4 Be Beryllium 9.012182	C Solid Hg Liquid H Gas Rf Unknown										Metals		Nonmetals				
				Alkali metals		Alkaline earth metals		Lanthanoids		Transition metals		Poor metals		Other nonmetals		Noble gases		
								Actinoids										
19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955912	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938045	26 Fe Iron 55.845	27 Co Cobalt 58.933195	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.64	33 As Arsenic 74.92160	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.796	
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90585	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.96	43 Tc Technetium (97.9072)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60	53 I Iodine 126.90447	54 Xe Xenon 131.293	
55 Cs Cesium 132.9054519	56 Ba Barium 137.327	57-71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.94788	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.227	78 Pt Platinum 195.084	79 Au Gold 196.966569	80 Hg Mercury 200.59	81 Tl Thallium 204.3853	82 Pb Lead 207.2	83 Bi Bismuth 208.98040	84 Po Polonium (209.9824)	85 At Astatine (209.9871)	86 Rn Radon (222.0176)	
87 Fr Francium (223)	88 Ra Radium (226)	89-103	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (266)	107 Bh Bohrium (264)	108 Hs Hassium (277)	109 Mt Meitnerium (268)	110 Ds Darmstadtium (271)	111 Rg Roentgenium (272)	112 Uub Ununbium (285)	113 Uut Ununtrium (284)	114 Uuq Ununquadium (289)	115 Uup Ununpentium (288)	116 Uuh Ununhexium (289)	117 Uus Ununseptium (288)	118 Uuo Ununoctium (294)	

For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.

Periodic Table Design and Interface Copyright © 1997 Michael Dayah. <http://www.ptable.com/> Last updated: May 27, 2008



57 La Lanthanum 138.90547	58 Ce Cerium 140.116	59 Pr Praseodymium 140.90766	60 Nd Neodymium 144.242	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92535	66 Dy Dysprosium 162.500	67 Ho Holmium 164.93032	68 Er Erbium 167.259	69 Tm Thulium 168.93421	70 Yb Ytterbium 173.054	71 Lu Lutetium 174.967
89 Ac Actinium (227)	90 Th Thorium 232.03806	91 Pa Protactinium 231.03688	92 U Uranium 238.02891	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)

Electron configuration!

Chemistry IS the transfer of electrons between atoms.

Periodic Table

- Atoms and ions with **full valence shells** are the **most stable** (have the **lowest energy**)
- Atoms **transfer or share valence electrons** in order to **fill their valence shells**

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18																													
1	H Hydrogen 1.00794																		2	He Helium 4.002602																												
3	Li Lithium 6.941	4	Be Beryllium 9.012182															5	B Boron 10.811	6	C Carbon 12.0107	7	N Nitrogen 14.0067	8	O Oxygen 15.9994	9	F Fluorine 18.9984032	10	Ne Neon 20.1797																			
11	Na Sodium 22.98976928	12	Mg Magnesium 24.3050															13	Al Aluminum 26.9815386	14	Si Silicon 28.0855	15	P Phosphorus 30.973762	16	S Sulfur 32.065	17	Cl Chlorine 35.453	18	Ar Argon 39.948																			
19	K Potassium 39.0983	20	Ca Calcium 40.078	21	Sc Scandium 44.955912	22	Ti Titanium 47.867	23	V Vanadium 50.9415	24	Cr Chromium 51.9961	25	Mn Manganese 54.938045	26	Fe Iron 55.845	27	Co Cobalt 58.933195	28	Ni Nickel 58.6934	29	Cu Copper 63.546	30	Zn Zinc 65.38	31	Ga Gallium 69.723	32	Ge Germanium 72.64	33	As Arsenic 74.92160	34	Se Selenium 78.96	35	Br Bromine 79.904	36	Kr Krypton 83.796													
37	Rb Rubidium 85.4678	38	Sr Strontium 87.62	39	Y Yttrium 88.90585	40	Zr Zirconium 91.224	41	Nb Niobium 92.90638	42	Mo Molybdenum 95.96	43	Tc Technetium (97.9072)	44	Ru Ruthenium 101.07	45	Rh Rhodium 102.90550	46	Pd Palladium 106.42	47	Ag Silver 107.8682	48	Cd Cadmium 112.411	49	In Indium 114.818	50	Sn Tin 118.710	51	Sb Antimony 121.760	52	Te Tellurium 127.60	53	I Iodine 126.90447	54	Xe Xenon 131.293													
55	Cs Cesium 132.9054519	56	Ba Barium 137.327	57-71															72	Hf Hafnium 178.49	73	Ta Tantalum 180.94788	74	W Tungsten 183.84	75	Re Rhenium 186.207	76	Os Osmium 190.23	77	Ir Iridium 192.222	78	Pt Platinum 195.084	79	Au Gold 196.966569	80	Hg Mercury 200.59	81	Tl Thallium 204.3833	82	Pb Lead 207.2	83	Bi Bismuth 208.98040	84	Po Polonium (209)	85	At Astatine (209.9871)	86	Rn Radon (222.0176)
87	Fr Francium (223)	88	Ra Radium (226)	89-103															104	Rf Rutherfordium (261)	105	Db Dubnium (262)	106	Sg Seaborgium (266)	107	Bh Bohrium (264)	108	Hs Hassium (277)	109	Mt Meitnerium (268)	110	Ds Darmstadtium (271)	111	Rg Roentgenium (272)	112	Uub Ununbium (285)	113	Uut Ununtrium (284)	114	Uuq Ununquadium (289)	115	Uup Ununpentium (288)	116	Uuh Ununhexium (289)	117	Uus Ununseptium (289)	118	Uuo Ununoctium (284)

For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.

Periodic Table Design and Interface Copyright © 1997 Michael Dayah. <http://www.ptable.com/> Last updated: May 27, 2008

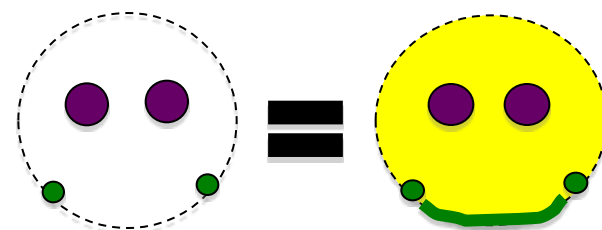
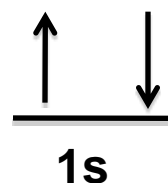
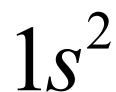


57	La Lanthanum 138.90547	58	Ce Cerium 140.116	59	Pr Praseodymium 140.90765	60	Nd Neodymium 144.242	61	Pm Promethium (145)	62	Sm Samarium 150.36	63	Eu Europium 151.964	64	Gd Gadolinium 157.25	65	Tb Terbium 158.92535	66	Dy Dysprosium 162.500	67	Ho Holmium 164.93032	68	Er Erbium 167.259	69	Tm Thulium 168.93421	70	Yb Ytterbium 173.054	71	Lu Lutetium 174.967
89	Ac Actinium (227)	90	Th Thorium 232.03806	91	Pa Protactinium 231.03688	92	U Uranium 238.02891	93	Np Neptunium (237)	94	Pu Plutonium (244)	95	Am Americium (243)	96	Cm Curium (247)	97	Bk Berkelium (247)	98	Cf Californium (251)	99	Es Einsteinium (252)	100	Fm Fermium (257)	101	Md Mendelevium (258)	102	No Nobelium (259)	103	Lr Lawrencium (262)

Noble Gases

- **Noble gases** are **extremely stable** because their electrons completely fill their outermost shell

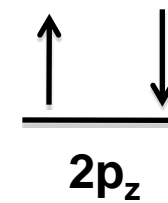
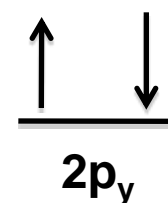
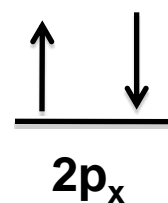
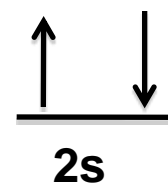
He



Ne



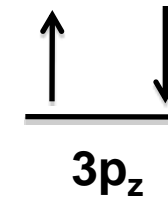
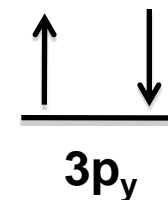
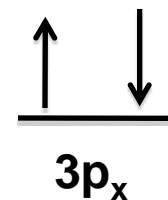
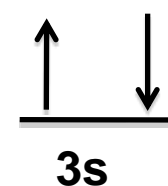
[He]



Ar



[Ne]



Noble Gases

- **Noble gases** are also called **inert gases**, since they are **so stable** that they **don't react** with many other elements

hydrogen 1 H 1.0079																						helium 2 He 4.0026						
lithium 3 Li 6.941	beryllium 4 Be 9.0122																						boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180
sodium 11 Na 22.990	magnesium 12 Mg 24.305																						aluminum 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948
potassium 19 K 39.098	calcium 20 Ca 40.078	scandium 21 Sc	titanium 22 Ti	vanadium 23 V	chromium 24 Cr	manganese 25 Mn	iron 26 Fe	cobalt 27 Co	nickel 28 Ni	copper 29 Cu	zinc 30 Zn	gallium 31 Ga	germanium 32 Ge	arsenic 33 As	selenium 34 Se	bromine 35 Br	krypton 36 Kr											
rubidium 37 Rb	strontium 38 Sr			niobium 41 Nb	molybdenum 42 Mo	technetium 43 Tc	ruthenium 44 Ru	rhodium 45 Rh	palladium 46 Pd	silver 47 Ag	cadmium 48 Cd	indium 49 In	tin 50 Sn	antimony 51 Sb	tellurium 52 Te	iodine 53 I	xenon 54 Xe											
cesium 55 Cs				tungsten 74 W	rhenium 75 Re	osmium 76 Os	iridium 77 Ir	platinum 78 Pt	gold 79 Au	mercury 80 Hg							radon 86 Rn											
francium 87 Fr				boron 106 Bh	bohrium 107 Bh	hassium 108 Hs	meitnerium 109 Mt	unnilium 110 Uun	ununium 111 Uuu	unbibium 112 Uub																		
				lanthanum 57 La	cerium 58 Ce	praseodymium 59 Pr	neodymium 60 Nd	promethium 61 Pm	samarium 62 Sm	europium 63 Eu	gadolinium 64 Gd	terbium 65 Tb	dysprosium 66 Dy	holmium 67 Ho	erbium 68 Er	thulium 69 Tm	ytterbium 70 Yb											
				actinium 89 Ac	thorium 90 Th	protactinium 91 Pa	uranium 92 U	neptunium 93 Np	plutonium 94 Pu	americium 95 Am	curium 96 Cm	berkelium 97 Bk	californium 98 Cf	einsteinium 99 Es	fermium 100 Fm	mandeleevium 101 Md	nobelium 102 No											

Be my friend!

No, thanks. I don't want friends.



Other Elements

Noble Gases

Outline

- Special Groups
- Salts
- Ionic Radii

- Special Groups
 - Noble Gases
 - Alkali Metals
 - Halogens
- Salts
- Ionic Radii

Alkali Metals

- **Alkali metals** have one more electron than noble gases
- To attain a stable, **noble-gas electron configuration**, alkali metals **lose 1 electron** to become +1 cations

The diagram shows a periodic table with red arrows pointing from the alkali metal column (Li, Na, K, Rb, Cs, Fr) to the noble gas column (He, Ne, Ar, Kr, Xe, Rn). Each arrow is labeled with $- 1 e^-$, indicating the loss of one electron to achieve a noble gas configuration.

hydrogen 1 H 1.0079																	helium 2 He 4.0026
lithium 3 Li 6.941	beryllium 4 Be 9.0122											boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180
sodium 11 Na 22.990	magnesium 12 Mg 24.305											aluminum 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948
potassium 19 K 39.098	calcium 20 Ca 40.078	scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.39	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80
rubidium 37 Rb 85.468	strontium 38 Sr 87.62	yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.94	technetium 43 Tc 98	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.9055	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29
caesium 55 Cs 132.91	barium 56 Ba 137.33	lanthanum 57 La 138.91	hafnium 58 Hf 178.49	tantalum 59 Ta 180.95	wolfram 60 W 183.84	reuterium 61 Re 186.21	osmium 62 Os 190.23	iridium 63 Ir 192.22	platinum 64 Pt 195.08	gold 65 Au 196.97	mercury 66 Hg 200.59	thallium 67 Tl 204.38	lead 68 Pb 207.2	bismuth 69 Bi 208.98	polonium 70 Po [209]	astatine 71 At [210]	radon 72 Rn [222]
francium 87 Fr [223]	radium 88 Ra [226]	actinium 89 Ac [227]	rutherfordium 104 Rf [261]	bohrium 105 Bh [262]	seaborgium 106 Sg [266]	meitnerium 107 Mn [268]	hassium 108 Hs [269]	tennessium 109 Ts [271]	oganeson 110 Og [271]	ununium 111 Uuu [272]	unubium 112 Uub [277]	ununium 113 Uuq [289]	unquadrium 114 Uuq [289]	unpentium 115 Uup [289]	unhexium 116 Uuh [289]	unseptium 117 Uus [289]	unoctium 118 Uuo [289]

* Lanthanide series

lanthanum 57 La 138.91	cerium 58 Ce 140.12	praseodymium 59 Pr 140.91	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europium 63 Eu 151.96	gadolinium 64 Gd 157.25	terbium 65 Tb 158.93	dysprosium 66 Dy 162.50	holmium 67 Ho 164.93	erbium 68 Er 167.26	thulium 69 Tm 168.93	ytterbium 70 Yb 173.04
actinium 89 Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]

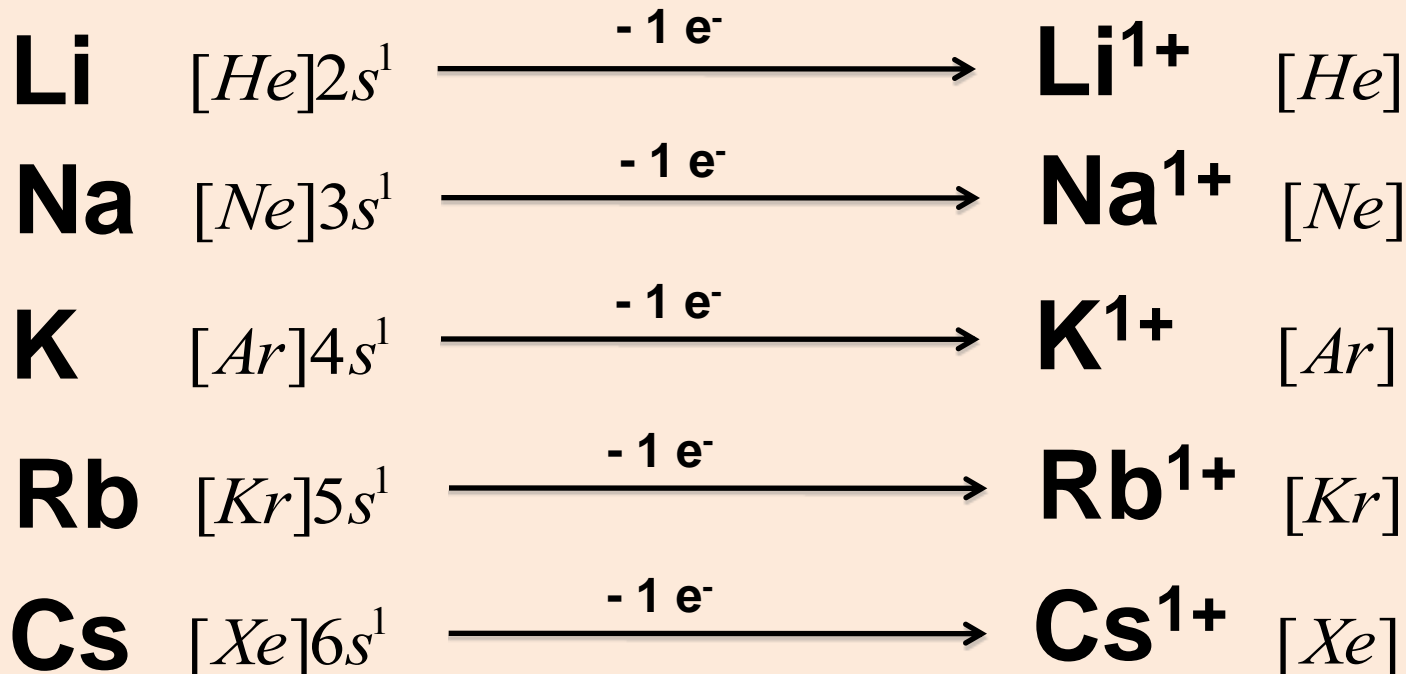
↑ Actinide series

Alkali Metals

Noble Gases

Alkali Metals

- Alkali metals have one more electron than noble gases
- To attain a stable, noble-gas electron configuration, alkali metals lose 1 electron to become +1 cations



* Lanthan

** Actini

Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No
[227]	232.04	231.04	238.03	[237]	[244]	[243]	[247]	[247]	[251]	[252]	[257]	[258]	[259]

Outline

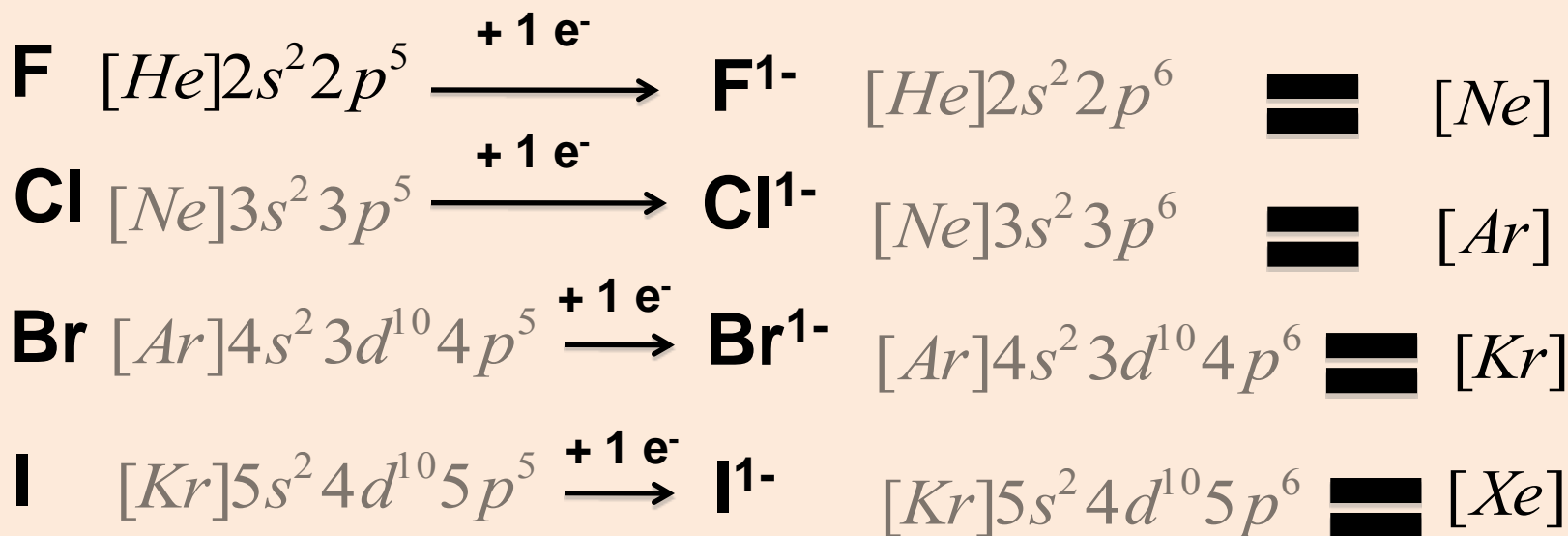
- Special Groups
- Salts
- Ionic Radii

- Special Groups
 - Noble Gases
 - Alkali Metals
 - Halogens
- Salts
- Ionic Radii

Halogens

- Alkali metals have one more electron than noble gases
- To attain a stable, noble-gas electron configuration, alkali metals lose 1 electron to become +1 cations

hydrogen 1 H 1.0079															helium 2 He 4.0026							
lithium 3 Li	beryllium 4 Be														boron 5 B	carbon 6 C	nitrogen 7 N	oxygen 8 O	fluorine 9 F 18.998	neon 10 Ne 20.180		
																				chlorine 17 Cl 35.453	argon 18 Ar 39.948	
																					bromine 35 Br 79.904	krypton 36 Kr 83.80
																					iodine 53 I 126.90	xenon 54 Xe 131.29
																					astatine 85 At [210]	radon 86 Rn [222]



* Lanthanide series

lanthanum 57 La 138.91	cerium 58 Ce 140.12	praseodymium 59 Pr 140.91	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europium 63 Eu 151.96	gadolinium 64 Gd 157.25	terbium 65 Tb 158.93	dysprosium 66 Dy 162.50	holmium 67 Ho 164.93	erbium 68 Er 167.26	thulium 69 Tm 168.93	ytterbium 70 Yb 173.04
actinium 89 Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]

** Actinide series

Outline

- Special Groups
- Salts
- Ionic Radii

- Special Groups
 - Noble Gases
 - Alkali Metals
 - Halogens
- Salts
- Ionic Radii

Other Atomic Ions

- Just like alkali metals and halogens, atoms of other elements lose or gain electrons to gain noble-gas electron configurations

hydrogen 1 H 1.0079						helium 2 He 4.0026	
lithium 3 Li 6.941	beryllium 4 Be 9.0122	boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180
sodium 11 Na 22.990	magnesium 12 Mg 24.305	aluminum 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948
potassium 19 K 39.098	calcium 20 Ca 40.078	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80
rubidium 37 Rb 85.468	strontium 38 Sr 87.62	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29
caesium 55 Cs 132.91	barium 56 Ba 137.33	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]

How many electrons do the atoms in each group above need to lose or gain to be like noble gases?

1	?	?	?	?	?	1	0
+1	?	?	?	?	?	-1	0

Electrons **lost** / **gained**

Ionic charge

Other Atomic Ions

- Just like alkali metals and halogens, atoms of other elements lose or gain electrons to gain noble-gas electron configurations

hydrogen 1 H 1.0079						helium 2 He 4.0026	
lithium 3 Li 6.941	beryllium 4 Be 9.0122	boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180
sodium 11 Na 22.990	magnesium 12 Mg 24.305	aluminum 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948
potassium 19 K 39.098	calcium 20 Ca 40.078	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80
rubidium 37 Rb 85.468	strontium 38 Sr 87.62	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29
caesium 55 Cs 132.91	barium 56 Ba 137.33	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]

How many electrons do the atoms in each group above need to lose or gain to be like noble gases?

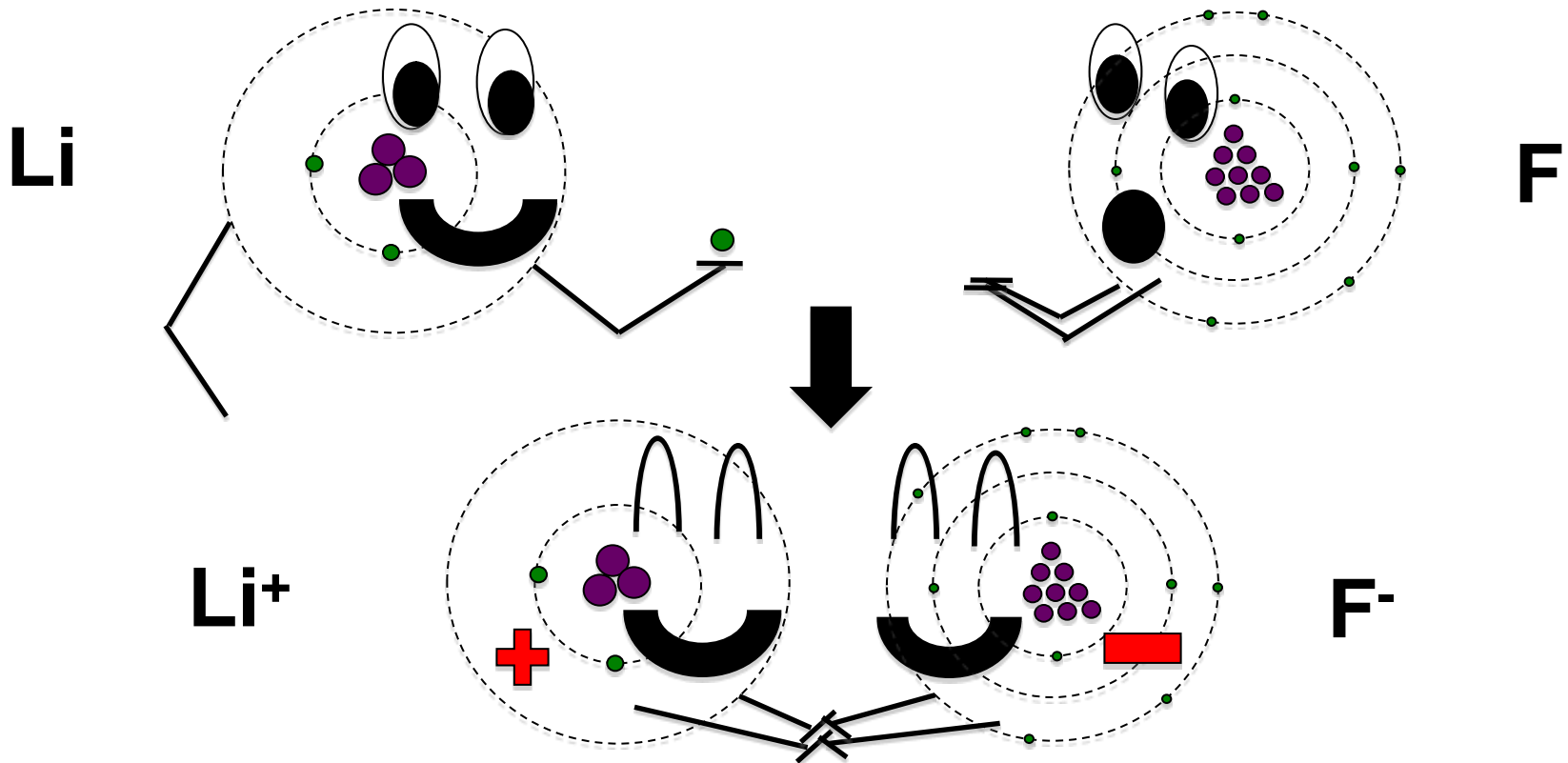
1 2 3 4 3 2 1 0
 +1 +2 +3 +4 -3 -2 -1 0

Electrons **lost** / **gained**

Ionic charge

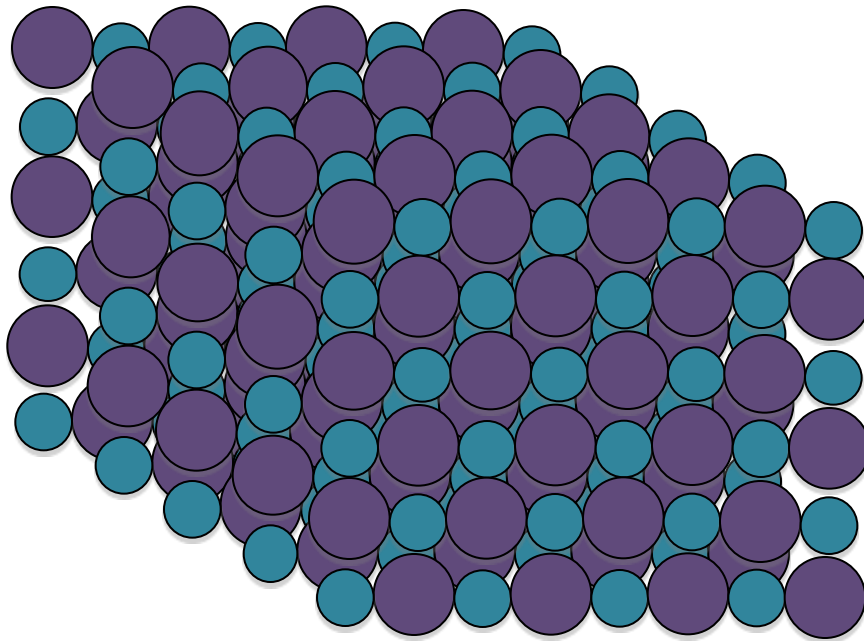
Salts

- **Alkali metals give up** an electron to become cations
- **Halogens accept** an electron to become anions
- **Cations** (positively charged ions) and **anions** (negatively charged ions) **attract** each other strongly.



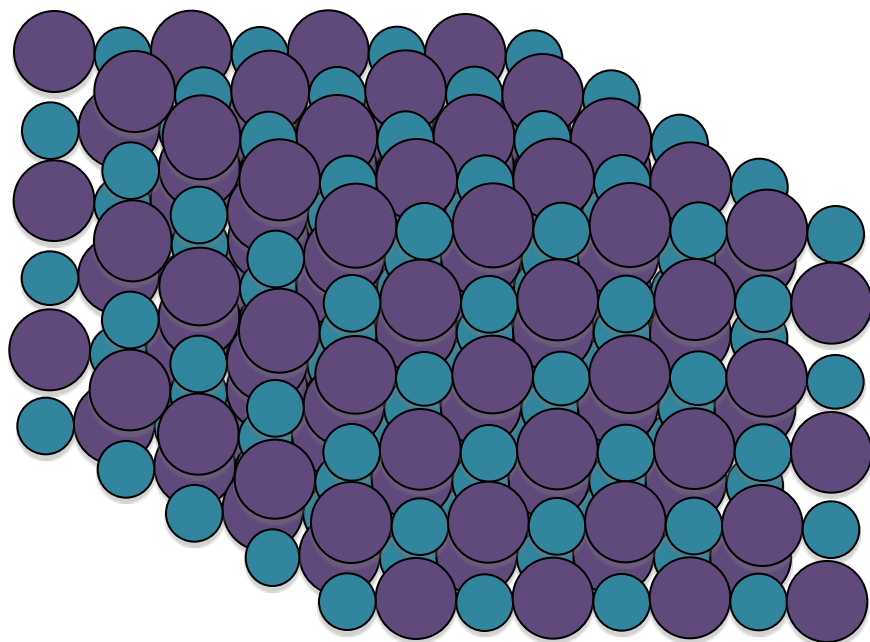
Salts

- **Salts** are **crystalline solids** of cations and anions



Salts

- **Salts** are **very stable** due to the strong attraction of cations and anions



Cl⁻



Na⁺

Because they need to give up or accept only **one electron**, **alkali metals** and **halogens** are very **reactive**.

Let's see what happens when we place a small amount of (some alkali metal) in water ...

Outline

- Special Groups
- Salts
- Ionic Radii

- Special Groups
 - Noble Gases
 - Alkali Metals
 - Halogens
- Salts
- Ionic Radii

Mini Quiz

- Rank the following atoms in order of increasing atomic radius:

Ge

O

C

Se

- How many electrons will the following atoms lose or gain to attain fully filled valence orbitals?

Na

In

Br

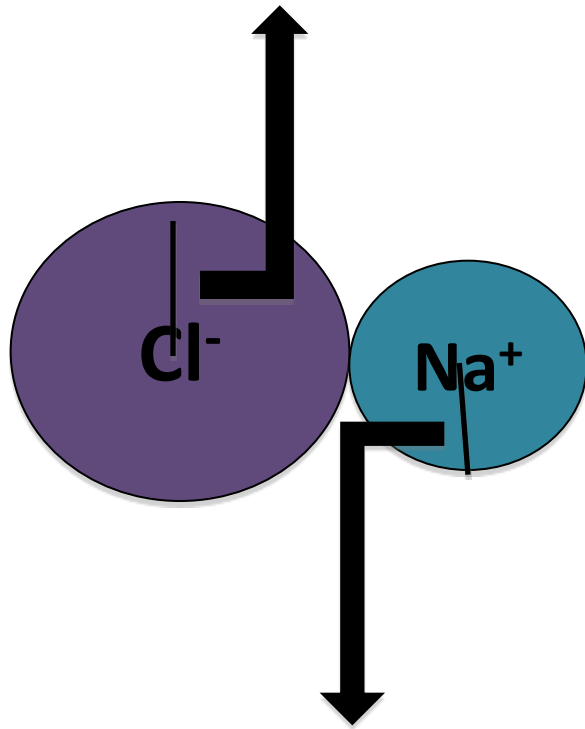
Bi

- What would the charges on the ions above after gaining or losing electrons?

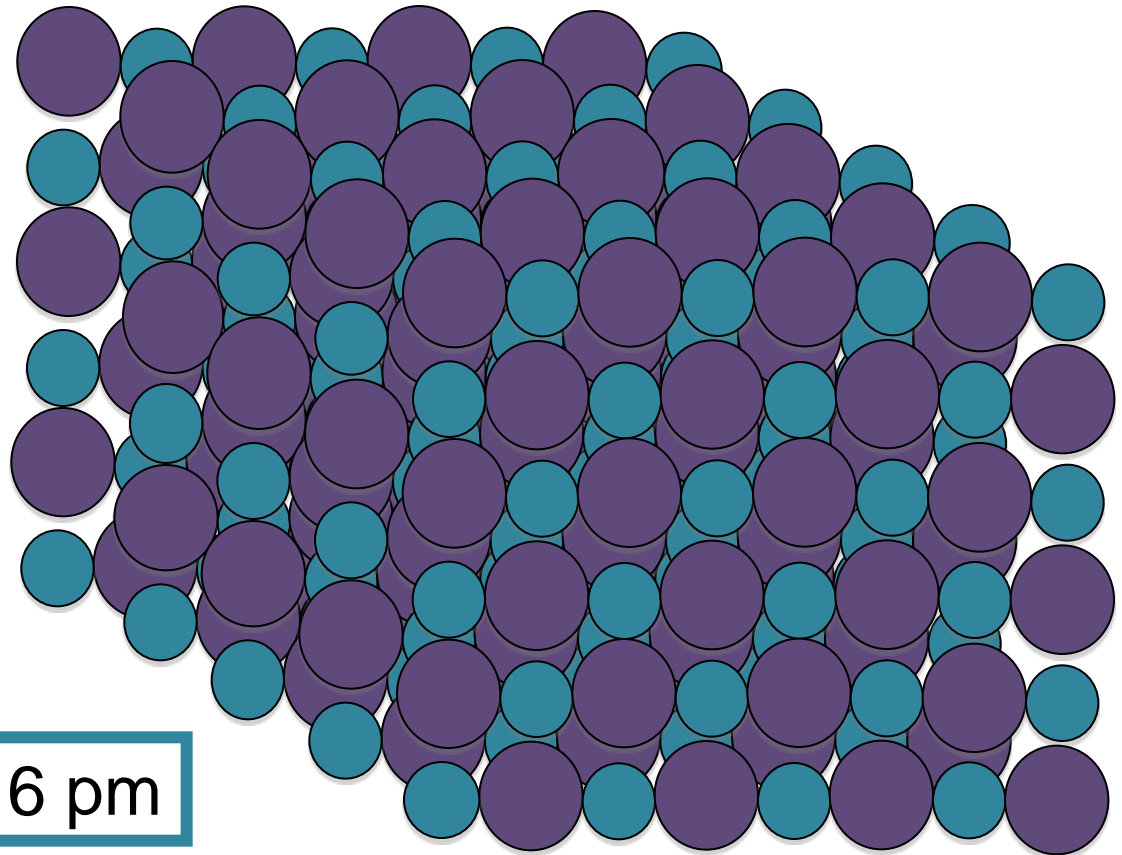
Ionic Radii

- We measure the radii of ions by measuring atom-atom distances in ionic solids (salts)

Ionic Radius (Cl^-) = 167 pm

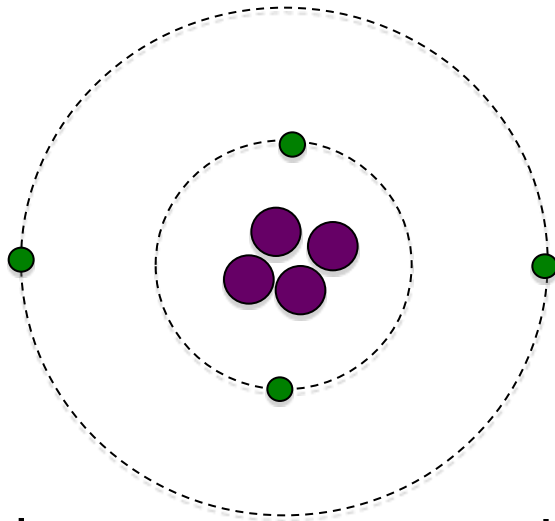


Ionic Radius (Na^+) = 116 pm



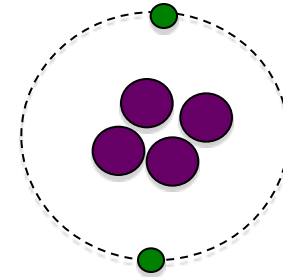
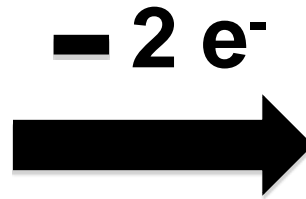
Cationic Radii

- Electrons push other electrons farther from the nucleus
- **Removing electrons** from an atom makes the remaining electrons move **closer to the nucleus**



Atomic Radius = 90 pm

Be

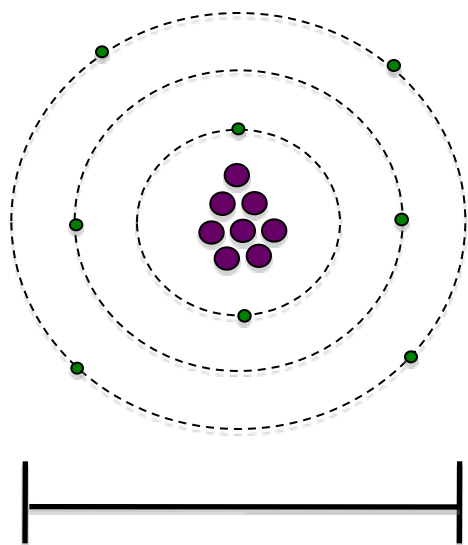


Ionic Radius = 59 pm

Be²⁺

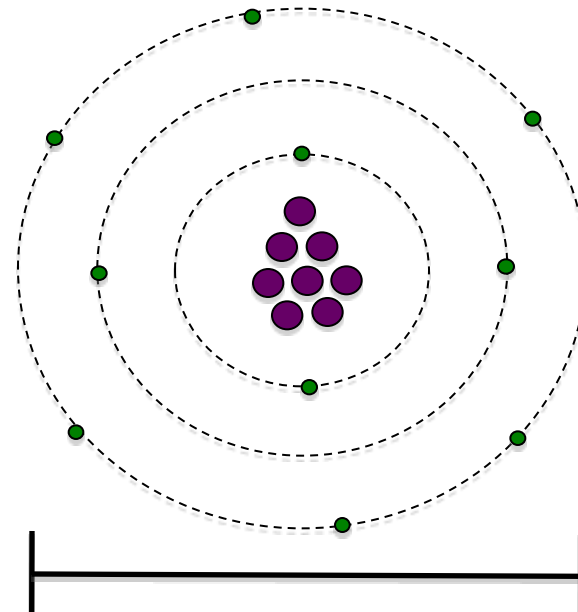
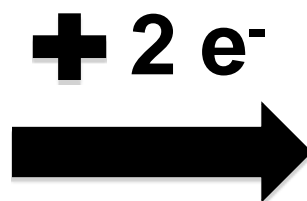
Anionic Radii

- Electrons push other electrons farther from the nucleus
- **Adding electrons** to an atom makes the remaining electrons move **farther from the nucleus**



Atomic Radius = 60 pm

O



Ionic Radius = 126 pm

O²⁻

Ionic Radii – Periodic Trends

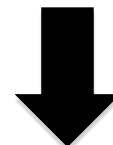
- Just like alkali metals and halogens, atoms of other elements lose or gain electrons to gain noble-gas electron configurations

Compared to neutral atom ...

hydrogen 1 H 1.0079						helium 2 He 4.0026	
lithium 3 Li 6.941	beryllium 4 Be 9.0122	boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180
sodium 11 Na 22.990	magnesium 12 Mg 24.305	aluminum 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948
potassium 19 K 39.098	calcium 20 Ca 40.078	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80
rubidium 37 Rb 85.468	strontium 38 Sr 87.62	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29
caesium 55 Cs 132.91	barium 56 Ba 137.33	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]



Positive Charge



Ionic Radius



Negative Charge



Ionic Radius

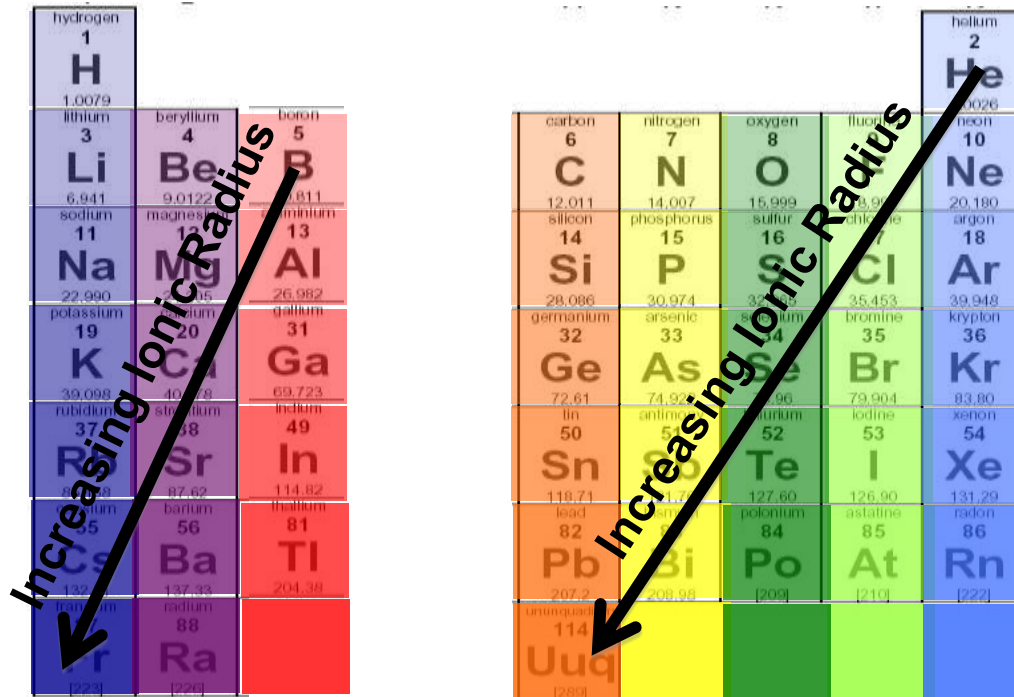
Electrons **lost** / **gained**

Ionic charge

1	2	3	4	3	2	1	0
+1	+2	+3	+4	-3	-2	-1	0

Ionic Radii – Periodic Trends

- Because **cations** are **smaller** than neutral atoms and **anions** are **larger** than neutral atoms, ionic radii follow a more complicated trend.



Cations
Ionic Radius
smaller than
Atomic Radius

Anions
Ionic Radius
larger than
Atomic Radius

Ionic Radii – Periodic Trends

- Rearranging the periodic table, we see that ionic radius approximately increases going from the smallest 3+ cation (B 3+) to the largest 4- anion (Pb 4-)

The image shows a periodic table with a diagonal arrow pointing from the top-right (Helium) to the bottom-left (Uranium) labeled "Increasing Ionic Radius". The table is color-coded by groups: Group 1 (purple), Group 2 (blue), Groups 13-18 (orange, yellow, green, light green, blue, dark blue), and Groups 3-12 (red, pink, light purple, dark purple, brown, black).

				helium 2 He 4.0026	hydrogen 1 H 1.0079			
carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180	lithium 3 Li 6.941	beryllium 4 Be 9.0122	boron 5 B 10.811	
silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948	sodium 11 Na 22.990	magnesium 12 Mg 24.305	aluminum 13 Al 26.982	
germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80	potassium 19 K 39.098	calcium 20 Ca 40.078	gallium 31 Ga 69.723	
tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29	rubidium 37 Rb 85.468	strontium 38 Sr 87.62	indium 49 In 114.82	
lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]	caesium 55 Cs 132.91	barium 56 Ba 137.33	thallium 81 Tl 204.38	
uranium 92 U [238]					francium 87 Fr [223]	radium 88 Ra [226]		

Anions
Ionic Radius
larger than
Atomic Radius

Cations
Ionic Radius
smaller than
Atomic Radius

Isoelectronic Atoms and Ions

- Two atoms or ions with the same number of electrons are **isoelectronic**
- When comparing two isoelectronic atoms or ions, the one with the **greater positive charge** has the **smaller radius**
- When comparing two isoelectronic atoms or ions, the one with the **greater negative charge** has the **larger radius**

- He
- H⁻
- Li⁺

hydrogen 1 H 1.0079								helium 2 He 4.0026
lithium 3 Li 6.941	beryllium 4 Be 9.0122	boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180	
sodium 11 Na 22.990	magnesium 12 Mg 24.305	aluminium 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948	
potassium 19 K 39.098	calcium 20 Ca 40.078	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80	
rubidium 37 Rb 85.468	strontium 38 Sr 87.62	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29	
caesium 55 Cs 132.91	barium 56 Ba 137.33	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]	

Mini Quiz

Place the following ions in order of increasing atomic radius



Place the following ions and atom in order of increasing atomic radius



hydrogen 1 H 1.0079								helium 2 He 4.0026
lithium 3 Li 6.941	beryllium 4 Be 9.0122	boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180	
sodium 11 Na 22.990	magnesium 12 Mg 24.305	aluminium 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948	
potassium 19 K 39.098	calcium 20 Ca 40.078	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80	
rubidium 37 Rb 85.468	strontium 38 Sr 87.62	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29	
caesium 55 Cs 132.91	barium 56 Ba 137.33	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]	

Summary

- Atoms lose or gain electrons to attain filled outer shells (noble-gas configurations)
- Salts form from anionic and cationic atoms
- Ionic radii are larger (smaller) in anions (cations) than in neutral atoms

Homework

- TBD